RECOGNITION OF DEGRADED PRINTED MARATHI CHARACTERS USING ZONE AND TEXTURE BASED FEATURES

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ABSTRACT

Designing vigorous and competent Optical Character Recognition (OCR) organism is stimulating and fascinating area in image processing. The OCR system aims to translate scanned text to a machine understandable text. To do so, numerous tactics exist for several scripts, languages and so far for good quality characters. Conversely, only delimited permutations of the same have been investigated for degraded printed Marathi characters. This paper focuses on developing an OCR system for such characters that consist of phases such as preprocessing, feature extraction, segmentation, classification and recognition, etc. Mutual information (MI), Mean Square Error (MSE) and Peak signal to noise ratio (PSNR) performance measures are used for estimation of enhanced image. Two statistical feature extraction techniques; zone based and texture based techniques are fused to recognize the characters using artificial neural network (ANN), support vector machine (SVM) classifiers. Proposed methodology's results are obtained in MATLAB R2015a. The work produces better values of accuracy, precision, recall and specificity, which are 93.47, 87.80, 97.46 and 90.75 respectively.

Keywords: Optical Character Recognition, degraded, Marathi, zone based, texture based, artificial neural network, support vector machine.

I. Introduction

India is a multi-script, polyglot country having 22 languages around, specifically, Assamese, Bodo, Bangla, Dogri, Gujarati, Hindi, Konkani, Kashmiri, Kannada. Marathi. Manipuri, Maithili, Malayalam, Nepali, Oriya, Punjabi, Sindhi, Santali, Sanskrit, Telugu, Tamil, and Urdu etc.Only 12 scripts have been used to write such languages. Sanskrit, Marathi, Hindi, Konkani, Nepali, Mathili, Dogri and Bodo etc., languages are written in Devnagiri script. Sindhi language is written in Devnagiri script in India whereas in Pakistan it's in Urdu script. Bangla, Manipuri and Assamese languages are transcribed by Bengali script. The script Gurumukhi is utilized to inscribe Punjabi language. Remaining languages have their specific scripts. Upper and lower case letters are absent in Indian languages. Maximum Indian languages are resulting from Ancient Brahmi. Such languages are phonetic in nature and therefore characters have precise shapes. Excepting Urdu all above languages are written from left towards the right direction (Khobragade et al., 2013). Devanagari script is used in numerous Indian languages as mentioned above, around the world more than 300 million individuals' practices this script. Devanagariscript is the establishment of Indian languages. Consequently, this script does a very chief role in the expansion of manuscripts typically This script and literature. acknowledged by a shirorekha, which unites the character's top in the word. Yet, in certain words, all the characters might be disengaged. The letters comprising of vowels, consonants, conjuncts etc., in this script are currently enumerated (Ramana Murthy et al., 2012). In today's technological world, it is necessary to have entire existing information in a digital format acknowledged by machines. In India, where there is a richness of information available in the form of books, documents, manuscripts, ancient texts, etc., those are conventionally presented in handwritten or printed form; such things are unsuitable when it comes to examining information between hundreds of pages. It should be digitized and renewed to a textual form with an aim to diagnose by machines doing explorations of a thousand of pages per second. It is also required to recover and mine the text which is deprecated. Only at that moment, the proper information about culture, tradition, history, etc., would be obtainable to the crowds. OCR has become one of the greatest fruitful applications in an area of artificial intelligence

and pattern recognition. To distinguish handwritten or printed texts in commonly used languages like English, Japanese, Chinese, etc., judiciously competent and reasonable OCR packages are commercially presented. OCR is the utmost indispensable fragment of a document analysis system, which converts the scanned magazines, books, text into machine comprehensible forms. Document analysis and recognition can be separated into 2 portions, which are printed, handwritten character recognition. The printed documents could be additionally allocated into 2 slices: degraded printed documents and good quality printed documents. Degradation of the text could have bleed-through, border smear, smear inside, low illuminations, unclearness, touching characters, broken characters etc. Refer figure1.



Figure 1. Document Analysis and Recognition

It is challenging to recognize printed Marathi characters in degraded documents because of high intervariation, intravariation between text and document background, noise, compound characters, etc. Likewise, due to the presence of modifiers at diverse locations OCR development for printed Marathi degraded characters is tough. Several authors have taken efforts on degraded printed other language characters, but no labor is found in Marathi language. It is conceivable to encourage approaches for degraded Marathi character recognition.

Rest of paper is organized as follows; related work is explained in section 2 in brief. Data collection is described in section 3. Various preprocessing techniques used are enlightened is section 4. Segmentation and feature extraction methods used are mentioned in sections 5 and 6 respectively. Brief description about classification and recognition phases are explained in section 7 and 8 correspondingly. Three performance measures for enhanced image are described in section 9.Performance metrics are described in section 10. In section 11, detail discussion of experimental results is present. Concluding part is mentioned in section 12.

II. Related Work

The literature review has been done, which is associated to technology influence in the study of diverse text recognition methods applied to various languages of handwritten and printed scripts. The study of Indian offline character recognition happening with the printed character recognition, regardless of the script then prolonged to the handwritten and characters and number recognition in numerous Indian scripts comprising Devanagari. Rotation invariant texture features and their practice in automated script identification consequences for the Chinese papers exposed that a substantial portion of the errors was because of papers wrongly classified as Persian. The causeof it is not completely perfect (Prathima et al., 2011). Certaininvestigation is also dedicated towards touching character segmentation, handwritten compound characters and word recognition in several Indian scripts. In the early 1970s, OCR work on the printed Devanagari script was initiated. Bansal (1999) has done abroadstudy of printed Devanagari text. An organism for Devanagari off-line handwritten character recognition by using directional information for features extraction is offered by U. Pal et al.(2007). A summary of the diverse script identification approaches under each of these types is described by Debashis Ghoshet al.(2010). B.V. Dhandraetal. (2006)offered an automatic method for word level script identification based on morphological reconstruction and is projected for 2 printed bilingual documents of Devnagari, Kannada holding English numbers. The method developed contains a classifier and feature extractor. To mine individual text lines from Indian printed documents havingcurve text lines or multi-oriented text lines, Water reservoir analogy is practiced(Hung-Ren Ko et al., 2009). Sudden noise in a sequence may break the usual transmission of states for this order, making it bizarre to train models. The policy use is compensating for certain negative effects of this noise. System attains a 98.88 percent accuracy rate on handwritten numerals (Pal et al., 2004). In the printed Gurmukhi script, diverse kinds of degradation acknowledged like as heavy printed characters, broken characters, touching characters, etc., problems allied with every degradation type (Jindal et al., 2007). Althaf et al., (2012) proficient easy off-line suggested and handwritten character recognition organism using radon feature extraction having for 270 features. recognition 90% rate Adaptive image contrast based document image binarization technique called as novel document image binarization is presented by Bolan Su et al. (2013). Two-stage parameterfree window-based binarization technique is demonstrated by Chiu et.al.(2012). Pixel-based evaluation technique with special concentration manuscripts, historical including on degradation, complex types of font is suggested Ntirogiann is et al.(2012).Hybrid by binarization technique by using which benefits of global, local thresholding are getting. Such technique is invented by Sokratis et.al. (2011).P atvardhan et al.(2012) provides a novel scheme depends on Wavelet Transform for document image binarization with ununiform enlightenment, tedious background. In (Neves et al., 2013) newer algorithm is explained by Carlos Alexandre Barros Mello et al., which treats diversely placed shadows, brightness deviation, front-back intervention, aspect variants, enlightenment, etc. In this algorithm detection, edge morphological operations are used to recognize a text onto an image. Apart from these, numerous techniques for various scripts, languages are present.

III. Data Collection

For the work, standard database is not available. For investigation purposes, degraded printed Marathi documents are collected from several places like Deccan College Postgraduate and Research Institute, Pune, The Bharat Itihas Sanshodhan Mandal Pune, The Bhandarkar Oriental Research Institute, Pune, Jaykar library of Savitribai Phule Pune University, The Vagdevata Mandir Dhule etc. For the job more than 1000 differently degraded printed Marathi documents have been used. 100 samples for each degraded printed Marathi character are used in this work.

IV. Preprocessing

Preprocessing could be defined as cleaning the image document and constructing it suitable for superior feature extraction. Numerous techniques are deliberated under it. Normalization is the procedure of renovating the randomsized image into typical sized image. It escapes inter-class variation among characters. An input image is normalized to size40×30 and then converted into a grayscale image for further processing as original image was colored one. Digital images are influenced by numerous kinds of noise that arises through acquisition practice because of document age, camera's or scanner's sensor, etc. Noise is the consequence of a fault in the image gaining course, which effects in pixel values that don't imitates the true intensities of the real one. Background noise and salt-pepper noise are 2kinds of noises those are very communal. The mean and standard median filters(Gonzalez, 2009) are types of spatial digital filtering method, often employed to clean Gaussian and salt-pepper noises within the input image. In this work, adaptive Gaussian filtering is applied to the image.

V. Segmentation

Binarization is the way through which grayscale image is altered into binary images depending on the pixel value. This is utilized to mine text from low eminence background. The pixel, which create character needs1 bit of data each. Depends on the pixel value black or white image is substituted by 0 or 1 correspondingly. Threshold based methodology is useful here. Thresholding is a method vital in image segmentation applications. The elementary idea of thresholding is to choose an optimal gray-level threshold value for splitting interested objects in an image from the background depending on their gray-level spreading(Khan, 2014). In this work all the pixels with threshold value greater than a threshold value (128) are set to 1 otherwise to 0.

VI. Feature Extraction

After attainment of pre-processing and the preferred level of segmentation, certain feature extraction technique applies to the segments to gain features that are followed by classification and post processing practices. It is crucial to emphasis on the feature extraction stage as it devises a noticeable influence on the effectiveness of the recognition system. Feature selection of a feature extraction technique is the single very significant factor in attaining a high recognition rate. Hence, the choice of a suitable feature extraction method conferring to the input to be applied wants to be done with extreme attention. Feature extraction techniques are categorized into statistical features, structural features, etc. Statistical features are resulting from the statistical circulation of points. They offer low complication, great speed etc. They might also be utilized for sinking the feature set dimension (Kumar & Bhatia, 2014). In this work, zoning and texture based statistical features are used. The frame enclosing the character is allocated into numerous overlapping or non-overlapping zones and the densities of the points and certain strokes in diverse areas are examined

and produce the features. Before feature extraction, image is skeletonized to achieve speeds up. Skeletonization is a practice for sinking foreground areas in a binary image to a skeletal remnant, which basically conserves the extent and connectivity of the novel area while flinging away maximum of the original foreground pixels. Also universe of discourse is applied to speed up the feature extraction process. The image is resized to the nearest multiple of 3 since3x3 windowing is used. Initially confirmed that the image consists of minimum 9 rows and minimum9 columns, zero padding is applied as required so that images can be divided into 3x3 zones. From 9 zones 9 features are extracted namely the number of horizontal lines, total length of horizontal lines, number of right diagonal lines, total length of right diagonal lines, number of vertical lines, total length of vertical lines, number of left diagonal lines, total length of left diagonal lines and the number of intersection points. Hence 9*9=81 features are extracted using the zoning method. Texture feature extraction is done using gray level co-occurrence matrix (GLCM) approach. In statistical texture analysis, texture features are calculated from statistical circulation of observed the permutations of intensities at stated positions relative to each other in an image. According to the number of intensity points in every permutation, statistics are categorized in firstorder, second-order and higher-order statistics. GLCM technique is a mode of mining second order statistical texture features. This tactic is used with a numeral of applications (Mohanaiah et al., 2013). In this paper, 22 texture features like Contrast, Correlation, Cluster Prominence, Dissimilarity, Energy, Entropy, Homogeneity etc., are used. These 22 features are fused with above mentioned 81 features: as a result total 103 features have been extracted in this work.

VII. Classification

Image classification examines the numerical assets of assorted image features and manages data into groups. Classification algorithms usually employ 2 steps of processing: training and testing. In the primary training step, characteristic properties of distinctive image features are secluded and depending on these unique descriptions of every classification category, i.e. Training class is produced. In the successive testing step, such feature-space divisions are utilized to classify image features. The training classes' depiction is an exceedingly significant constituent of the classification practice. Different methods have been invented since recent few decades for classifying an unknown sample into a predefined class. Usually classification and recognition in the OCR are made by using holistic or analytic approaches (Kulkarni et al., 2015). Top down approach is utilized in holistic strategy for full word recognition and segmentation problem is removed in such case. Conversely, bottom up approach is utilized in analytic strategy for characters recognition. In this paper ANN, SVM classifiers are used.ANN consists of several nodes, which mimic human brain's biological neurons. The links are used to connect the neurons that communicate with each other. The nodes can receive input data and execute plain operations on it. The effect of such operations is conceded to other neurons. The outcome at every node is called its node value or activation. Every link is allied with weight (Das et al., 2017). ANNs are proficient of learning that happens with varying weight values. Especially Feedforward neural network has been used here. It has series of layers. The first layer has a relation from the network input. Every succeeding layer has a relation from the preceding layer. The last layer generates the network's output. This network could be used for any type of input to output mapping.

SVM tool is founded on statistical learning theory projected, in year 1979, by Vapnick. The chief incentive of this system is the probabilistic search of the limits which diminish errors and empirical risk but exploiting the margin of parting. Itcreates a separation of regions with optimal hyper planes in a multidimensional data space that guarantees the learning systems convergence. Uses of SVM concern, statistical analysis and pattern recognition (Amara et al., 2014).SVM is a binary classification method. The training stage comprises of searching the support vectors for every class and forming a function which signifies an optimal split-up margin between the support vectors of diverse classes. Accordingly, it is conceivable to gain an optimal hyper plane for class parting (Neves & Zanchettin, 2012).

VIII. Recognition

Recognition is the phase of image processing and it's a process to identify and detect an object or attribute in a digital image. For recognition purposes k-nearest neighbor (KNN) has been used. KNN classifies data using the nearest-neighbor technique. It classifies every row of the data in the sample into one of the groups in training using the nearest-neighbor routine. Sample and training should be matric es with the equal size. It allows specifyingthe number of nearest neighbors used in the classification, by default it's 1(Anava & Levy, 2016).In this work input image is recognized to one of 49 (13 Vowels, 36 Consonants) classes.

IX. Performance Measures For Enhanced Image

Several assessment factors are there. Mutual information (MI), Mean Square Error (MSE) and Peak signal to noise ratio (PSNR) parameters are utilized for evaluation of enhanced image.

Mutual Information

It belongs to probability or information theory that calculates the amount of information that one variable comprises about another one. MI is the resemblance measure between images. It qualifies extent of information in units like shannons or bits obtained about one variable through the other(Liu et al., 2016).

Mean Square Error

MSE is the cumulative squared error between two given images. A minor MSE value means lesser error. There is a reverse relation between MSE and PSNR.

Where, MSE - Mean Square Error. M x N – Image size. X - Imaginative Image. R - Restored Image.

Peak Signal to Noise Ratio

PSNR is the ratio between the maximum possible signal power and corrupted imagepower. Class and size of both input and output image must be equivalent. PSNR is utilized as quality depth between images. The greater PNSR value in the renovated image affords superior class. PSNR is defined by Decibel unit(Sara et al., 2019). In case of grayscale image it is described as,

X. Performance Metrics

To assess the recital of proposed OCR model for the degraded Marathi character recognition study consider the key recital metrics like accuracy, precision rate, recall rate, and specificity rates. The outcome of confusion matrix used for the computation of performance metrics. The key components of confusion matrix are:

- True Positive (tp) = correctly identified
- True Negative (tn) = correctly rejected
- False Positive (fp) = incorrectly identified
- False Negative (fn) = incorrectly rejected

Accuracy

The recognition accuracy is computed using following formula:

Accuracy =
$$\frac{\text{tp} + \text{tn}}{\text{tp} + \text{tn} + \text{fp} + \text{fm}}$$

Precision Rate

Accuracy considers all recovered records; however, it can similarly be surveyed at a given cutoffposition, considering only the most noteworthy results returned by the structure. This measure is called precision. This can be processed utilizing underneath recipe:

Precision =
$$\frac{tp}{tp + fp}$$

Recall Rate

Review in data recovery is the part of the report that are significant to the query that are effectively recovered. This can be computed using below formula:

$$\text{Recall} = \frac{\text{tp}}{\text{tp} + \text{fn}}$$

Specificity

Specificity is also known the true negative rate that measures the proportion of actual negatives that are appropriately recognized as such (e.g., the percentage of healthy people who are suitably acknowledged as not having the condition).

Specificity =
$$\frac{\text{tn}}{\text{tn} + \text{fp}}$$

XI. Experimental Results And Discussion

For experimental purposes, the dataset is prepared by using 100 samples for every character and further separated in 2 set with the ratio of 70:30. This character dataset is made up to 49 characters with 100 samples of each. Hence the total dataset size is about 4900 characters. The dataset is divided into 70:30 ratios to makeup train and test set correspondingly. After that, various phases of image processing such as preprocessing, segmentation, feature extraction, etc., are applied. During classification, ANN, SVM classifiers are employed. Randomly images are provided for training and testing in the ratio of 70:30.Table1 represents the results assessed by above mentioned MI. MSE and PSNR parameters for one sample of each 49 characters.

Alphabet	MI Voluo	MSE	PSNR
Image	wir value	Value	Value
Image1	3.03319	5.31417	38.5017
Image2	3.01437	11.1267	35.2024
Image3	3.11792	10.1683	35.5482
Image4	2.77282	11.9917	35.1005
Image5	2.93035	8.78083	36.454
Image6	3.14281	13.1083	34.7578
Image7	2.52818	10.54	34.5826
Image8	3.07424	6.71833	37.2105
Image9	2.25255	15.4492	33.777
Image10	2.34793	3.89417	40.1598
Image11	2.21889	5.04833	37.2654
Image12	2.86853	12.6483	34.869
Image13	2.49577	1.34333	44.3388
Image14	3.42864	3.40417	40.1167
Image15	3.12588	10.18	35.6337
Image16	3.07242	9.01667	36.2947
Image17	3.06432	13.1242	34.8399
Image18	2.59182	7.21417	36.2291
Image19	3.22832	5.11417	38.7129
Image20	2.9126	22.5775	32.4403
Image21	3.37496	3.735	39.8978
Image22	2.86372	14.7558	34.0215
Image23	2.50782	8.5875	35.5221
Image24	3.12865	10.4183	35.9719
Image25	3.21056	6.035	38.0826
Image26	3.05854	13.7883	34.7119
Image27	3.37285	4.49833	38.9526
Image28	3.388	4.61083	39.5973
Image29	3.14258	5.39167	38.7467

Image30	2.93341	11.7325	35.3267
Image31	3.1568	9.72667	35.6496
Image32	2.89659	14.6783	34.2665
Image33	3.62141	1.40167	43.877
Image34	3.3818	3.195	40.3456
Image35	2.81164	14.5617	34.3012
Image36	3.2241	4.635	38.8227
Image37	3.23237	5.5325	37.961
Image38	3.3096	5.52333	38.1072
Image39	3.58828	2.06167	42.7471
Image40	3.17564	3.06583	41.4958
Image41	3.28741	4.2725	39.4492
Image42	3.3778	4.56	38.9396
Image43	2.89785	12.0583	35.4645
Image44	3.33043	3.90583	39.5197
Image45	3.41085	2.27667	41.8638
Image46	3.54499	2.2775	41.9086
Image47	2.88273	12.0633	35.1624
Image48	2.94039	23.8658	32.5416
Image49	2.95128	13.5567	34.5236

TABLE1. Results of MI, MSE and PSNR.

The comparative results of zoning features, GLCM features and proposed fused (zoning+ GLCM) feature with ANN classifier for 4900 characters are shown in Table2, these results are measured in terms of accuracy, precision, recall and specificity. The accuracy using proposed feature extraction techniques is 93.47 which is better than 86.44 of zoning features, 86.72 of GLCM features. The Precision values of Zoning features and GLCM features are 73.62, 73.87 respectively, which are lesser than that of proposed features. In case of a recall, proposed features offering slightly improved value. The specificity value of proposed features is 90.75 whereas as for zoning features it is 80.34 and for GLCM features it is 80.99.

	Zoning Features	GLCM Features	Proposed (Zoning+ GLCM) Features
Accuracy	86.44	86.72	93.47
Precision	73.62	73.87	87.80
Recall	97.26	97.06	97.46
Specificity	80.34	80.99	90.75

TABLE2. Comparative results of zoning, GLCM and proposed (zoning+ GLCM) feature with ANN classifier.

Table3 shows the comparative results of zoning features, GLCM features and proposed fused features with SVM classifier. The accuracy using proposed feature extraction techniques is 91.34 which is better than 89.01 of zoning features, 90.03 of GLCM features.

The Precision values of Zoning features and GLCM features are 75.20, 74.55respectively, which are lesser than that of proposed features. In case of a recall, proposed features offering marginally better value. The specificity value of proposed features is 82.31.

	Zoning Features	GLCM Features	Proposed (Zoning+ GLCM) Features
Accuracy	89.01	90.03	91.34
Precision	75.20	74.55	76.42
Recall	93.14	93.10	95.33
Specificity	90.75	82.31	82.31

TABLE3. Comparative results of zoning, GLCM and proposed (zoning+ GLCM) feature with SVM classifier.

Table2andTable3experimentalresultsareshown in following figures.



Fig1:- Accuracy Rate Performance



Fig2:- Precision Rate Performance

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Fig4:- Specificity Rate Performance









Fig7:- Classifiers Evaluation using Zone + EGLCM Features

There is no correlated effort told so far for the degraded printed Marathi character recognition, therefore it becomes hard to estimate the offered model performance with related approaches, but the modern tactics designed for the degraded printed English character recognition convenient to prepared dataset and measured their accuracy performances for the assessment resolution. Table4 shows the comparative study of all approaches conveyed those existing in (Namane& Meyrueis,2008; Liu, 2014;Hamsaveni& Prakash, 2017; Ramalingam& Bhojan, 2017; Ceniza et al., 2018) with the proposed method.

Methods	Accuracy (%)	Recognition Time (Seconds)
Namane & Meyrueis, 2008	81.99	2.45
Liu, 2014	84.34	1.82
Hamsaveni & Prakash,2017	78.38	2.78
Ramalingam & Bhojan,2017	86.53	3.04
Ceniza et al., 2018	79.49	1.73
Proposed	93.47	1.49

TABLE4. Performance analysis with similar methods

XII. Conclusion

This part of work predominantly focused on recognition of degraded printed Marathi characters. The standard dataset was not available so prepared on its own. The dataset contains 4900 characters, including 100 samples for all 49 Marathi characters. Initially processing preprocessing, image steps segmentation are applied. Zoning and GLCM feature have been extracted and merged with an aim to achieve better results. While doing classification and recognition, prepared dataset is divided in 70:30 ratios for training and testing purpose. ANN, SVM classifiersare used in this work. Using Proposed (Zoning+ GLCM) features with ANN classifier the values of accuracy, precision, recall and specificity are 93.47, 87.80, 97.46 and 90.75 respectively. The analysis of the suggested approach with analogous techniques shows that the performance is significantly greater for the recognition of degraded printed Marathi character with the very less computation work. The other methods using the comparable data show the deprived accuracy and higher computation labors. The work uses prepared

computation labors. The work uses prepared dataset, so features extraction techniques and classification techniques are applied only on the dataset prepared. In future, there could be methodology which performs well on diverse datasets. Various languages are existing in the world. The techniques in this work are applicable only for Marathi language. For other languages other techniques might be used.

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